


CORNELL EXTENSION BULLETIN 857

Safe Home Wiring and Electric Cords

Lucille J. Williamson

Dorothy W. Cousens



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Safe Home Wiring and Electric Cords

Lucille J. Williamson and Dorothy W. Cousens

YOU CAN

- . . . plan a better electric system for your home
- . . . take better care of your system
- . . . get greater satisfaction from appliances
- . . . make simple repairs to cords and appliances
- . . . get more for the money you spend for electricity

IF YOU

- . . . understand a few of the fundamentals of electricity
- . . . read the information on the name plates of appliances and understand the meaning of the terms used
- . . . develop a few skills that will help you to make satisfactory repairs

Safe Home Wiring

The Electric Current

THE name plate on your meter tells the kind of current supplied by your power company. It is probably 115 or 230 volt alternating current with a frequency of 60 cycles. If the voltage is 230 your house is wired so that most of the circuits carry 115 volt current and those for heavy-duty appliances, such as water heaters and ranges, carry 230 volt current.

Your electric power depends on the voltage of the current and its intensity. Intensity is expressed as amperes. The fuse in each circuit is labeled in amperes to show the greatest load that is safe to place on that circuit.

The name plate on electrical equipment carries information about the kind of current to which it is adapted and the load it places on the circuit. For example, an iron that has on the name plate 1000 watts, 115 volts, A. C. should be used only on a circuit that supplies 115 volt alternating current. The iron would probably be ruined if it were used on a direct current (D.C.) circuit. There are some hotels and a few residential districts that have direct current so that the traveler is wise to carry an iron that can be used on either alternating or direct current.

Any 115 volt appliance would be damaged if used on a 230 volt circuit. In many foreign countries the usual household voltage is 220. Travel irons are available that can be adapted to either 115 or 220 volts by simple adjustments of a screw or two.

The power requirement of motors is usually rated in amperes and that of lights and heating appliances in watts. To determine the ampere rating of appliances rated in watts, divide the rated wattage by the rated voltage. For example, a 1000 watt iron will place a load of 8.7 amperes on a 115 volt circuit. The calculation is $1000 \text{ watts} \div 115 \text{ volts} = 8.7 \text{ amperes}$.

The 8.7 ampere iron and a 5 ampere vacuum cleaner would give a combined load of $8.7 + 5$ or 13.7 amperes. One 100 watt light bulb would add almost another ampere to the circuit. This would be the greatest load that could be carried by a 15 ampere fuse. When in doubt, you can assume that the branch circuits in your home will carry 15 ampere fuses with safety but that heavier fuses should not be used.

Your Electric System

Electric Circuits

The path over which the current travels is called the circuit. Each circuit that comes from the fuse box is called a branch circuit.

Electric Wiring

Copper wire is used in circuits because it is one of the best conductors of electrical current. Since copper is expensive, you will want to have the smallest diameter wire used that will safely carry the load. However, if the wire is too small it will overheat, the insulation will be damaged, and there may be a fire. Furthermore, appliances will operate badly and you will pay for electrical energy that is wasted in heat energy.

The National Electric Code sets standards for your circuits. The copper wire in the usual home circuits must be at least as large as No. 14 and the fuse in such a circuit should not be heavier than 15 amperes. If the next larger wire, No. 12, is used, the circuit will have a 20 ampere capacity and a 20 ampere fuse may be used.

Solid wires are generally used for permanent wiring, and strands of many fine wires for cords that will be handled and moved about. The strand of twisted wires is much more flexible than the solid wire of the same copper content. It is important that all of the fine wires in a strand be attached to the connecting screws. Avoid breaking these wires when making repairs.

Your builder and electrician can provide the kind of wiring you need. The National Board of Fire Underwriters has a set of rules called The National Electric Code, which serves as a guide for safe wiring.

You will be wise to take the advice of your electrician to install an electric system that more than meets the minimum requirements. You should have at least a few 20 ampere circuits (No. 12 wire) and there should be provision for adding more circuits later. You can usually expect to own more appliances later than you now have.

Fuses and Other Circuit Breakers

The fuse, a safety device, is part of the circuit (figure 1). It is made of a material that melts and cuts off the current if the circuit becomes dangerously overloaded. A damaged fuse has to be replaced with a new one.

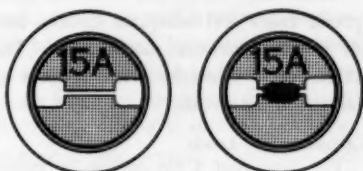


Figure 1. Fuses

1a. Good fuse 1b. Blown fuse

A new device called a circuit breaker is replacing fuses in many systems. Instead of a material that melts, there are metal parts that spring apart when the metal becomes hot. A switch when reset brings the metal parts together again after the circuit has cooled off.

The circuit breaker that can be reset has several advantages. You do not have to keep a supply of fuses; you do not have to hunt for a fuse; and you cannot replace a blown fuse with a penny, a fuse heavier than the circuit should have, or any other conductor that might endanger your home.

Your Responsibility

You are responsible for proper fuses or circuit breakers, for the kinds of extension cords you use, for the load on the circuit, and for the kind of appliances you use.

Appliances Suited to the System

When purchasing an appliance, you should be sure it is designed to operate on the voltage available and that it will not draw more current than the system is designed to carry.

Circuit Loads and Overloads

Fifteen amperes is the heaviest load that most household circuits can carry with safety. Circuits that are used for laundry and kitchen appliances should be of wire heavy enough that a 20 ampere fuse can be used with safety. Power companies and builders try to get 20 ampere lines in homes for these purposes.

Possible Overloads by Heating Equipment

Any equipment such as irons and range units that have heating elements use much more electrical energy in proportion to their size than do lights

and motor-driven appliances such as refrigerators, vacuum cleaners, and mixers. The largest unit on the range, rated at about 2000 watts on high heat, will use as much electrical energy in one hour of continuous operation at high heat as will a 100 watt light bulb in 20 hours.

Household motors add relatively little to the electric bill. They do require special fuses and adequate circuits because there is a brief heavy demand for power when the motor starts. There are special fuses called "delayed action fuses" that take a few seconds overload without blowing and without damage to the circuit.

Calculation of Loads

The load that a circuit can be expected to carry without blowing a fuse may be calculated by multiplying the voltage by the amperes stated on the fuse. Thus (since volts \times amperes = watts) $115 \times 15 = 1725$ watts, the maximum load for No. 14 copper wire, and $115 \times 20 = 2300$ watts, the maximum load for No. 12 copper wire.

The load is the sum of the demand of every motor, light, and heating appliance on the circuit. Load A and load B are examples of the kinds of loads on household circuits.

LOAD A		LOAD B	
Two 50 watt lights	100 watts	A clock	3 watts
Three 100 watt lights	300 watts	An electric heater	600 watts
One toaster	1000 watts	A coffee maker	500 watts
	<hr/>	An iron	1000 watts
	1400 watts		<hr/>
			2103 watts

Load A could operate on a 15 ampere fused circuit. Load B would require a 20 ampere fuse and should be on a circuit of No. 12 wire.

Faulty Circuits

Short Circuits

Breaks in insulation and contact with other metal sometimes establish a shorter, easier path for the electric current than the one provided for it. Such a situation is called a short circuit and may cause great damage or a fire. When there is reason to suspect danger of a short circuit, the trouble should be located and corrected before the circuit or appliance is used. Watch for danger signals such as frayed cords, sparking, and small shocks when you handle appliances. The proper fuse helps protect the system against such damage and the user against danger.

Grounded Circuits

The grounding wire provided on some appliances, when properly connected, serves to lead off stray currents and prevents shocks which might otherwise occur, due to short circuit conditions. Many appliances, such as

ranges and washing machines, have ground wires built in. Others leave the installation of grounding equipment to the licensed electrician. Ask the electrician if an appliance is grounded or should be grounded.

Low Voltage

Low voltage is one of the most common causes of trouble with appliances. It is brought about by overloading the home system, by adding too many appliances to one circuit, and by using cords that are long and of small wire. An iron that heats slowly may heat rapidly when an adequate extension cord is substituted for one that is too small. A toaster that is slow to heat when used in an old house that has been converted into several apartments with overloaded circuits may heat faster when it is used in a home with adequate wiring. Low voltage slows up motors and heating devices and causes lamps to be dim. Motors may stall and burn out.

You will cause the voltage to be low if you use long cords with wires too small to carry the load easily; also, such cords will overheat. Only heavy cords with asbestos insulation should be attached to or used as extension cords for heating appliances.

Cost of Electrical Energy

How much electrical energy you use to operate an appliance depends upon the wattage of the appliance and the length of time you operate it. Thus $1000 \text{ watts} \times 4 \text{ hours} = 4000 \text{ watt hours}$. Since the watt is a small unit of power, electric bills are calculated on the basis of the kilowatt (1000 watts) times hours. Thus the example above would be stated as 1 kilowatt $\times 4 \text{ hours} = 4 \text{ kilowatt hours}$. The rate per kilowatt hour becomes less as you use more electrical energy. For example, your rate card might read:

First	10 kilowatt hours or less,	30 cents
Next	40 kilowatt hours,	4 cents each
Next	50 kilowatt hours,	3 cents each
Next	100 kilowatt hours,	2 cents each
Above 200 kilowatt hours,		1 cent each

If 150 kilowatt hours were used most months and a new radio that would use 25 kilowatt hours a month were added, the rate for the added electricity would be 2 cents a kilowatt hour or 50 cents per month. How much a radio uses depends on the wattage of the set and the hours it is kept turned on.

If you have an appliance with automatic control, such as an iron or oven with a thermostat, you will have to know how much of the time the current is on in order to calculate the cost of operation. For example, if you press a heavy, damp fabric with a 1000-watt iron, the current probably will not cut off, and you will use 1 kilowatt hour in one hour. The same iron might be

cut off half the time when you iron a light, dry fabric so that in one hour only half a kilowatt hour would be used. If the electricity costs 3 cents a kilowatt hour, the cost of operation on the heavy, damp material would be 3 cents an hour and on the lighter material $1\frac{1}{2}$ cents an hour.

Cord and Connections—Care and Repair

The Homemaker's Responsibility

YOU, the homemaker, can do much to keep your electrical appliances in good working order. However, most of the actual repairing of these appliances must be done by the trained technician. Repair work on built-in outlets, ceiling lamps, thermostats, and motors and the replacement of heat units should be done by competent electricians. Regulations for safety have been established by the National Electric Code. Any repairs should meet these regulations. Violations may invalidate fire insurance policies.

Some "Musts" for Appliances

1. When you purchase a new appliance, an instruction book generally accompanies it. You should become familiar with the directions and operate the appliance according to the manufacturer's instructions. Manufacturers can usually supply these booklets if you do not have them for the appliances you now own. Keep the directions close at hand for ready reference.
2. Keep appliances clean, dry, and oiled as specified by the manufacturer.
3. Grasp the plug and not the cord when you disconnect an appliance from an outlet.
4. Attach the cord to an appliance such as an iron, toaster, percolator, or waffle iron before you connect it to the outlet and turn it on, to prevent repeated "sparking," which corrodes the prongs. Corrosion causes a poor connection, decreasing the efficiency of the appliance.
5. Take proper care of cords by hanging them over a broad peg, a large spool, or two coat hooks placed a few inches apart. Do not hang them on a nail or crowd them into a drawer. Do not run cords over radiators, steam pipes, door sills, or under rugs.
6. Prevent short circuits and danger of shock by repairing braid and insulation as soon as the cord becomes worn. The life of most cords can be extended considerably if you wrap worn spots with friction tape or plastic electrician's tape as soon as a worn place or frayed spot appears.

7. Keep cords dry, and handle connected appliances only when hands and shoes are dry. These are safety measures to prevent shock.

8. Faucets, radiators, and other plumbing fixtures are joined to metal pipes and wires that go into the ground. To prevent shock, which can be serious, avoid touching these grounded metals when handling appliances connected to an electric circuit.

9. Use a fuse of the correct rating for each circuit and appliance.

10. Do not overload your circuit. Consider 1700 to 1800 watts the maximum load of one circuit unless you know your wires will safely carry more.

11. Repair immediately appliances that are not in good working order.

12. When you connect an appliance make sure that the cord is placed so that it will not be an accident hazard. If the cord is allowed to cross floors, table tops, and kitchen work surfaces, someone may be injured, the appliance is likely to be damaged, or other objects may be knocked over.

13. Avoid dropping cords or swinging them against hard surfaces. Such misuse often breaks the plug caps or other attachments.

14. Avoid using radios or other appliances in the bathroom. Many deaths from electrocution are caused by radios falling into bathtubs full of water.

Making Simple Electrical Cord Repairs

Householders can learn to make safely such minor repairs as replacing plug caps and taping or replacing worn cords. As skill and knowledge are gained, more complicated repairs may be attempted. These may include replacing heater plugs for irons, toasters, and percolators; installing feed-through switches; and repairing small lamps by replacing cord or worn lamp sockets. Complicated repairs on elaborate switches and convenience outlets should be made by trained electricians. One small mistake may cause costly damage.

General Suggestions

1. Very careful work is required in simple electrical repairs as well as in more complicated ones. If you sit comfortably at a table with feet flat on the floor or on a foot rest you will avoid much unnecessary fatigue. A sturdy firm work surface at a comfortable height is essential.

2. Never do any repair work on **LIVE** wires or circuits. Always disconnect the appliance and the cord from the outlet before starting repairs. Failure to do this can cause electrocution.

3. Do not touch any live wire, connected socket, or lamp with wet hands. Do not handle any connected appliance, cord, outlet, or switch while standing on wet ground, wet floors, or in water. Water acts as a grounding means

for electric current so that a person with wet hands or feet becomes a good conductor for the current and runs the danger of a severe electrical shock or electrocution.

Tools and Supplies

Use the proper tool to make the job easier and to avoid injury to yourself and to the appliance. You should have at least the following tools:

- a screw driver to loosen and tighten screws
- side cutting pliers or old shears to cut cord lengths and wires
- scissors or shears to cut away outer and inner insulation
- needle and coarse thread or friction tape to bind the braid
- box or container of screws, nuts, and other small parts
- pan or box for holding the screws, nuts, and other small parts as they are removed

Type and Size of Cord for Each Job

The use of the correct size and type of cord is important to the safe and satisfactory use of electrical equipment and appliances. If an extension cord is required, use the same type of cord for it as that attached to the appliance.

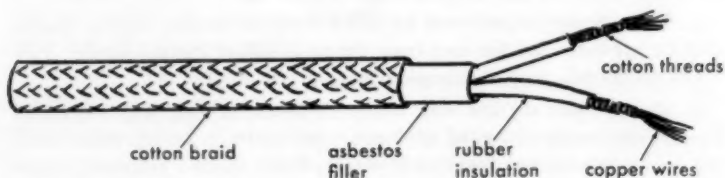
Select cords and appliance parts that carry the stamp of approval of the Fire Insurance Underwriters' Laboratories.

The three types of cord commonly used for household electrical appliances and equipment are:

1. Parallel lamp or rip cord - sizes 16 to 18 - rubber or plastic covered
Use: to connect lamps, small household appliances such as radios, clocks, fans

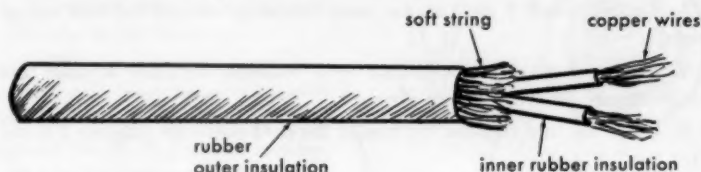


2. Heater cord - sizes 14 to 18 - asbestos insulation, braid covered
Use: to connect toasters, irons, percolators, sandwich grills



3. Appliance cord or medium duty – sizes 16 to 18 – special jackets to protect against abrasion, grease, or moisture.

Use: to connect appliances, vacuum cleaners, food mixers



Preparation of Cord for Repairs

1. Cut the worn parts from the disconnected cord. Remove the outer insulation by clipping it with sharp scissors. For a lamp cord, remove $\frac{3}{4}$ inch of the inner insulation and the threads around the copper wires. For appliance and heater cords, remove $1\frac{1}{2}$ to 2 inches of the outer insulation and $\frac{3}{4}$ inch of the asbestos filler and threads.

2. The exposed wires should be bright and clean. If the wires are dark, clean them by scraping them with a knife or by polishing them with fine sandpaper (No. 00). Be careful not to cut or break the tiny copper wires.

3. Twist the strands of each wire tightly together. This keeps the single copper wires from escaping when the wire is fastened under a screw and from coming in contact with wires from the opposite terminal.

4. Check to be sure the prepared end of the wire is the correct length for the place you are using it. The inner insulation should extend up to the binding screw and the exposed wire should make one complete turn around the screw but should not overlap.

5. Wind thread, friction tape, or electrician's plastic tape around the outer braid or insulation at a point just inside the plug or socket to which the cord is being connected. This will prolong the life of the cord as well as give it a neater appearance.

Making an Extension Cord

The type of cord used for extension cords should fit the purpose for which it is to be used. For example, lightweight rubber or plastic covered cord should be used for small lamps, radios, fans, and the like; cotton braid, asbestos-insulated cord should be used for heating appliances; and medium-duty rubber cord should be used for appliances with small motors, such as vacuum cleaners and electric mixers.

Attaching Cord to Heavy-duty Cord Connector

1. Remove the screws holding the two parts of the cord connector together (figure 2 a).

2. Remove from the cord 1 to 1½ inches of outside rubber or cotton braid and the inner filler. Be careful not to cut through the inner insulation and the tiny copper wires.

3. Remove about ¾ inch of the inner insulation around the two sets of wires.

4. After the inner insulation has been removed, carefully separate and cut the threads from the copper wires.

5. Insert the cord into the top end of the cord connector (figures 2 b and c).

6. Bind the outer cotton braid or rubber insulation with thread or a narrow strip of friction tape where the cord enters the outlet.

7. Twist the strands of copper wires into two tight cables.

8. Wrap the wires around the binding screws **JUST ONE COMPLETE TURN IN A CLOCK-WISE DIRECTION**. Avoid overlapping the wires around the screws.

9. Tighten the screws down firmly making sure that there are no exposed or loose wires.

10. Reassemble the cord connector (figure 2 c) by replacing the two screws that hold the two parts together.

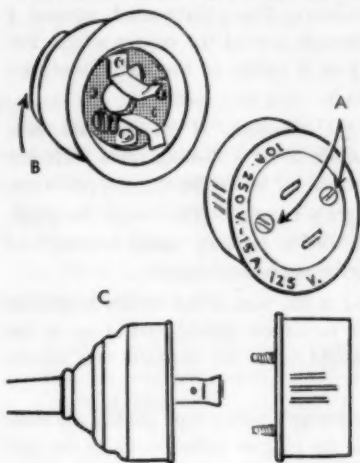


Figure 2. Attaching an extension cord to a cord connector and attachment plug cap
a. Screws holding two parts together
b. Opening for cord
c. Side view of cord connector

Attaching Cord to Plug Cap

1. Prepare the end of cord as in steps 2, 3, and 4 just preceding.
2. Put the cord through the top opening of the attachment plug cap (figure 3 a).
3. Bind the cord with heavy thread or a narrow strip of friction tape where the cord enters the plug cap. Check to be sure the thread or tape extends well up into the opening of the plug cap.

4. Scrape off $\frac{3}{4}$ inch of the inner insulation, being careful not to cut the small wires.

5. Separate and cut the threads from the copper wires.

6. Place an insulated wire around each plug prong (figure 3 b) and wrap the exposed ends around the binding screws, making just one complete turn. The insulation should extend up to the screws so that no wires are exposed except under the screw heads.

7. Tighten the screws firmly.

8. Replace the paper disk insulator (figure 3 c).

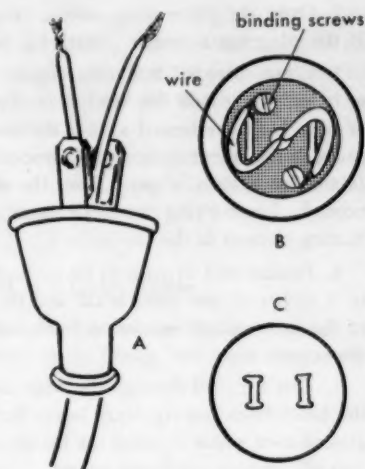


Figure 3. Plug cap

- a. Side view with cord inserted in plug cap
- b. The insulated wires brought around prongs and twisted ends fastened securely under screw heads
- c. Paper disk

Replacing Heater Cords and Plugs

Very often, difficulty with heating appliances can be traced directly to the cord. Cord trouble usually occurs near or in the plug. To help avert this trouble, always disconnect the appliance by grasping the plug cap instead of the cord. Also, when the cord braid shows sign of wearing or fraying, tape the worn place with friction tape. Heater cords deteriorate faster than light cords or "non-heat" appliance cords because of the heat that develops when the cord is being used. Other trouble spots may be found in the appliance plug. This plug gets very hot because of its closeness to the appliance and after much use the small copper wires break away from the binding screws in the plug.

When the heater cord becomes badly worn, discard it and replace with a new cord of the correct size and type for the appliance.

Attaching Cord to a Heater Plug

1. Use heater cord with braid covering and asbestos insulation.

2. Open the heater plug, noting carefully how it is assembled (figure 4). If the plug has a switch (figure 5), be careful not to dislocate the spring.

3. Clean corroded terminals (figure 4 a) by scraping them with a knife or by polishing with fine sandpaper. However, if the terminals are very rusty or have been overheated so that the metal shows dark rainbow colors, check to see if the terminals fit tightly around the inserted prongs of the appliance. If the springiness is gone from the terminals, a new heater plug will be needed. Loose-fitting terminals cause sparking, which in turn injures the heating element of the appliance.

4. Prepare end of cord to be connected to plug (figure 4 b). Remove $1\frac{1}{2}$ to 2 inches of the outer braid and the asbestos insulation. Remove $\frac{3}{4}$ inch of the inner rubber insulation from the wires. Take care not to cut or break the copper wires.

5. Pass the cord through the wire coil and bushing (figure 4 c). To keep the braid from fraying, wrap heavy thread or a narrow strip of friction tape around cord where it enters the heater plug. Be sure outer braid extends well into plug before tightening screws.

6. Twist the bare copper wires tightly together. With a screw driver loosen the binding screws of the terminals (figure 4 d) and wrap the twisted wires

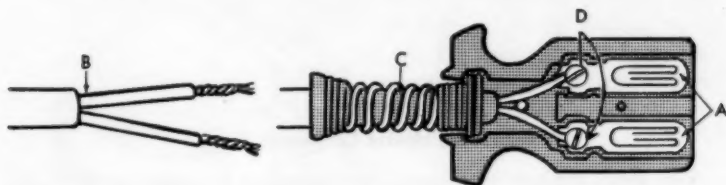


Figure 4. Replacing cord on a heater plug

- a. Terminals
- b. Prepared end of heater cord
- c. Cord passed through bushing and spring
- d. Twisted wires fastened under screw heads

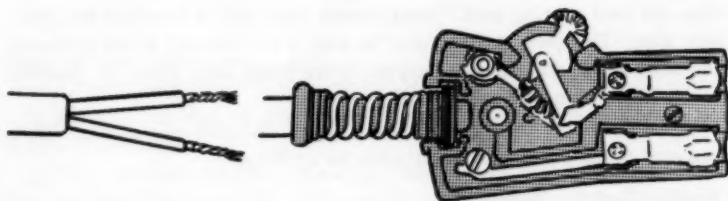


Figure 5. Heater plug with switch

CLOCKWISE around the screw one complete turn. Tighten the screws firmly. Place the cord, wire coil, and terminals on one of the halves of the heater plug and make any necessary changes for it to fit into the intended space. The insulation on the wires should extend up to the screws so that no wires are exposed except under the screw heads.

7. Fasten the two halves of the heater plug together. Note: If the heater plug has an off-on switch, attach the twisted copper wires to the binding screws near the top opening of the heater plug.

Connecting a Cord to a Lamp Socket

Badly worn and frayed lamp cords create an accident hazard that can be easily avoided by replacement with new cord. Plastic or rubber covered rip cord may be used.

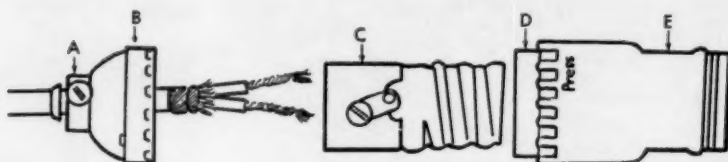


Figure 6. Connecting a cord to a lamp socket

- a. Bushing with screw
- b. Cap
- c. Porcelain or bakelite socket base
- d. Paper shell
- e. Brass shell

Attaching Cord to a Single Bulb Socket

Caution: Do not remove the old cord from a lamp until you read steps 1 through 4 below.

1. Examine the lamp carefully to see how the cord is placed in the lamp. Refer to figure 6 to recognize the parts of a lamp socket. It is generally better not to remove the screw (figure 6 a) in the base of the socket that fastens the socket to the lamp base.

2. Take the lamp socket apart by pressing on the shell where the word "Press" is stamped and pull sidewise on the socket.

3. Pull the cord up through the cap (figure 6 b). Disconnect the old cord from the socket base (figure 6 c).

4. Fasten one end of the new cord securely to the old cord. Pull the joined cords carefully down through the base or standard of the lamp.

5. Prepare the end of the new cord to be fastened to the socket base. If rip cord is used, separate the two sections for about $1\frac{3}{4}$ to 2 inches. If the cord is braid covered, remove about $1\frac{3}{4}$ inches of the braid. Then remove $\frac{3}{4}$ inch of the insulation and twist each set of fine copper wires together. To prevent the rip cord from splitting farther apart, wrap heavy thread or a narrow strip of friction tape around the cord where it enters the socket.

6. Wrap the twisted wires **CLOCKWISE** around the screws **ONE COMPLETE TURN**. Tighten the screws firmly. The insulation should extend up to the screws so that no wires are exposed except under the screw head.

7. Slide the inner paper shell (figure 6 d) and the brass shell (figure 6 e) back over the porcelain or bakelite base, press the socket together, and twist gently until the notches click into place.

8. Pull the cord from the base of the lamp until it is taut. Tighten the screw that holds the socket in the lamp base if it has been loosened or if a new lamp socket has been used to replace an old one.

9. Fasten a plug cap to the other end of the cord as described on page 12 or use one of the new self-locking type plug caps.

HOW TO MAKE CUPBOARD STORAGE DEVICES

L. LEOLA COOPER

